Bonneville Power Administration
Fish and Wildlife Program FY99 Proposal Form

Section 1. General administrative information

Incidence and effects of gas bubble trauma on early life stages of salmonid and resident fishes rearing in shoreline areas of the Hanford Reach and below Bonneville Dam in the Columbia River

Bonneville project number, if an ongoing project 9080

Business name of agency, institution or organization requesting funding
US Geological Survey, Biological Resources Division, Columbia River Research Laboratory

Business acronym (if appropriate) USGS-BRD

Proposal contact person or principal investigator:

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Subcontractors.

Organization	Mailing Address	City, ST Zip	Contact Name
none			

NPPC Program Measure Number(s) which this project addresses.

5.6E.1 This study should focus on.....b) the symptoms of gas bubble trauma related to both lethal and non-lethal effects on juvenile and adult salmon and other aquatic species.

NMFS Biological Opinion Number(s) which this project addresses.

Biological Opinion: 16. The BPA, COE, and BOR shall participate in the development and implementation of a monitoring and evaluation program to investigate the effects of dissolved gas supersaturation.
NMFS gas bubble disease research plan: Objective 2.1) Continue field research correlating gas bubble disease signs with mortality of resident fish in the lower Snake and mid- and lower Columbia rivers.

Other planning document references.

Subbasin.

Lower mid-Columbia River mainstem subbasin

Short description.

Determine the incidence and significance of gas bubble trauma (GBT) in salmonid fry and larval and juvenile resident fishes rearing in shallow shoreline areas where the ability to use depth for hydrostatic compensation is limited.

Section 2. Key words

Mark	Programmatic Categories	Mark	Activities	Mark	Project Types
X	Anadromous fish		Construction		Watershed
*	Resident fish		O & M		Biodiversity/genetics
	Wildlife		Production		Population dynamics
	Oceans/estuaries	X	Research		Ecosystems
	Climate	*	Monitoring/eval.	X	Flow/survival
	Other		Resource mgmt		Fish disease
			Planning/admin.		Supplementation
			Enforcement		Wildlife habitat enhancement/restoration
			Acquisitions		

Other keywords.

gas supersaturation, gas bubble trauma

Section 3. Relationships to other Bonneville projects

Project #	Project title/description	Nature of relationship
none		

Section 4. Objectives, tasks and schedules

Objectives and tasks

Obj 1,2,3	Objective	Task a,b,c	Task
1	Determine the incidence and severity of GBT in salmonid fry and larval and early juvenile resident fishes in shorelines	a b c	Collect fish in the field Examine for signs of GBT Monitor gas saturation levels in collection areas
2	Examine how dissolved gas supersaturation (DGS) may influence growth, survival, and vulnerability to predation of key taxa	a b	Expose larvae and juveniles to various levels of DGS in the laboratory and monitor growth, survival, and signs of GBT. Expose fry and juveniles with signs of GBT to predators in the laboratory

Objective schedules and costs

Objective #	Start Date mm/yyyy	End Date mm/yyyy	Cost %
1	10/1998	09/2000	50%
2	10/1999	09/2001	50%

Schedule constraints.

If sampling years (1999-2000) have low levels of supersaturation (low-flow years), an additional year of field work may be necessary.

Completion date.

2001

Section 5. Budget

FY99 budget by line item

Item	Note	FY99
Personnel	GS-12 6 mths, GS-9 12 mths, GS-5 12 mths	$82,501
Fringe benefits	30%	24,750
Supplies, materials, non-expendable property	Gas meter, laboratory & field supplies	8,500
Operations & maintenance	Boat, vehicle, gear, laboratory O&M	11,000
Capital acquisitions or improvements (e.g. land, buildings, major equip.)		
PIT tags	# of tags:	
Travel	Field work per diem	15,000
Indirect costs	Administrative overhead 38%	53,865
Subcontracts		
Other		
TOTAL		$195,616

Outyear costs

Outyear costs	FY2000	FY01	FY02	FY03
Total budget	$198,000	$160,000		
O&M as % of total	6%	5%		

Section 6. Abstract

The goal of this study is to determine the incidence and significance of gas bubble trauma (GBT) in salmonid fry and larval and juvenile resident fishes rearing in shallow shoreline areas where the ability to use depth for hydrostatic compensation is limited. This research will aid managers in assessing how dissolved gas supersaturation (DGS) may affect survival of dominant Columbia River fish species during their early life history (a potentially critical period in the formation of year-class strength) and thus evaluate the effects of dam operations such as spill which affect DGS levels. Young-of-the-year fishes will be collected in shoreline areas of the Hanford Reach and below Bonneville Dam in the Columbia River and examined for signs of GBT. Levels of gas saturation will be monitored concurrently. Additionally, laboratory studies will be conducted to determine how gas supersaturation may influence growth, survival, and vulnerability to predation of key taxa. This work is part of FWP objectives to investigate the symptoms of gas bubble trauma related to both lethal and non-lethal effects on

juvenile and adult salmon and other aquatic species. Field work will be conducted in 1999-2000, and laboratory research, data analysis, and manuscript preparation during 1999-2001.

Section 7. Project description

a. Technical and/or scientific background.

Show how the proposed work is a logical component of an overall conceptual framework or model that integrated knowledge of the problem. The most significant previous work history related to the project, including work of key project personnel on any past or current work similar to the proposal, should be reviewed. All work should be adequately referenced and listed at the end of this field.

Spilling water at dams can result in increased dissolved gas supersaturation (DGS), which can cause gas bubble trauma (GBT) in fish. In the Columbia River, water may have gas supersaturation levels exceeding 120% during peak flow periods. Gas supersaturation levels in shoreline areas of the Hanford Reach have been recorded as high as 120-130% (Paul Wagner, personal communication). To determine if GBT is occurring in juvenile salmonids, smolts passing dams are monitored for gas bubbles. However, there has been little research on the effects of DGS on salmonid fry and on early life stages of resident fishes. Larval and young juvenile fishes may be particularly vulnerable to GBT because many species rear in shallow shoreline areas where the ability to use depth for hydrostatic compensation is limited. Furthermore, shallow shoreline areas may have elevated levels of supersaturation due to solar heating, since gas solubility decreases with increasing temperature (Weitkamp and Katz 1980). Taxa particularly dependent on optimal conditions in shoreline areas for maximum growth and survival during critical early stages of rearing are subyearling fall chinook salmon Oncorhynchus tshawytscha (Key et al.1994), cyprinids, suckers, and American shad Alosa sapidissima (Gadomski and Barfoot, unpublished data).

Signs of gas bubble trauma are species-specific and vary with ontogeny. Gas bubbles have been observed to accumulate in the gut, yolk sac, fins, mouth, gill cavity, and peritoneal cavity of larval fish (Jones and Lewis 1976; Nebeker et al. 1977; Weitkamp and Katz 1980; Cornacchia and Colt 1984; McDonough and Hemmingsen 1985; Counihan et al. In press), hindering normal swimming abilities and behavioral patterns, and causing membrane ruptures. Another observed sign in larval fish is overinflation of the swimbladder, which may particularly affect small fish because they exhibit the greatest change in density (Cornacchia and Colt 1984; Shrimpton et al. 1990). Newly-hatched chinook salmon fry develop large gas bubbles posterior to the yolk sac if exposed to very high levels of supersaturation (128-190%) (Rucker and Kangas 1974; Zirges and Curtis 1975). Although signs of GBT in chinook fry exposed to intermediate gas pressures have not been described, Alderdice and Jensen (1985) suggested that sensitivity thresholds for salmonid fry are near 104 and 110% for chronic and acute GBT, respectively. Gas bubble trauma signs were observed in 10 to19-d-old larval striped bass Morone saxatilis at total gas pressures as low as 103%, with increased mortality documented at 106% (Cornacchia and Colt 1984). In contrast, eggs and newly-hatched fry of steelhead trout O. mykiss were not affected by total gas saturation levels of 127%, whereas at swim-up (16 days posthatch) mortality ranged from 99% at 127% saturation, to 45% at 115% saturation. The effects of GBT on older juvenile fishes, particularly salmonids, have been studied more extensively than effects on larval fishes. Gas bubbles in juvenile fishes have been observed on the lateral line, fins, eyes, body surface, and gills (Dawley and Ebel 1975; Weitkamp and Katz 1980). Species-specific effects of gas supersaturation on larvae and juveniles of most fishes in the Columbia River, however, are unknown.

We propose to collect larval and young juvenile fishes from shoreline areas of the Hanford Reach and below Bonneville Dam in the Columbia River, and conduct field examinations for signs of GBT. The Hanford Reach and below Bonneville Dam are the only free-flowing sections of the Columbia River in the United States. The Hanford Reach contains spawning habitats of the last major population of mainstem Columbia River fall chinook, with significant amounts of rearing habitat for newly-emerged (30-40 mm) fall chinook fry (Key et al. 1994). The area below Bonneville Dam contains spawning habitats for salmonid stocks (in particular, fall chinook salmon) located in vulnerable shallow shoreline areas. Gas supersaturation in shoreline areas could result in significant direct mortality of rearing salmonid fry, or indirect mortality due to increased vulnerability to predation. Mesa and Warren (1997) found that larger (about 100 mm in length) juvenile chinook salmon exposed to 130% TDG showed an increase in vulnerability to predation, although vulnerability of smaller fry exhibiting signs of GBT has not be examined.

This work is directly applicable to 1994 Fish and Wildlife Program (FWP) objective 5.6E.1: A focus on.....b) the symptoms of gas bubble trauma related to both lethal and non-lethal effects on juvenile and adult salmon and other aquatic species,≅ NMFS biological opinion 16: AThe BPA, COE, and BOR shall participate in the development and implementation of a monitoring and evaluation program to investigate the effects of dissolved gas supersaturation,≅ and NMFS gas bubble disease research plan objective 2.1: AContinue field research correlating gas bubble disease signs with mortality of resident fish in the lower Snake and mid- and lower Columbia rivers.≅

Key project personnel have extensive experience relevant to the proposed project. Dena Gadomski and Craig Barfoot have conducted research on larval and juvenile fishes in limnetic and littoral areas of the Columbia River for the past five years (1993-1997; BPA Project 90-078), resulting in the following manuscripts: Gadomski and Barfoot (In press), Barfoot et al. (In review), Barfoot (In preparation), Gadomski et al. (In preparation). Additionally, Thomas Poe and Dena Gadomski have studied predation on juvenile salmonids in the Columbia River Basin resulting in the following manuscripts: Poe et al. 1991, Vigg et al. 1991, Gadomski and Hall Griswold (1992), Gadomski et al. (1994), Petersen and Gadomski (1994), Petersen et al. (1994), and Poe et al. (1994). Matt Mesa of the Columbia River Research Laboratory will act as technical advisor. He has four years of extensive experience on various aspects of gas bubble trauma in salmonid fishes (Mesa et al. 1994; Mesa et al. 1996; Mesa and Warren 1997).

b. Proposal objectives.

Our goal is to determine the incidence and severity of gas bubble trauma in salmonid fry and in larval and juvenile resident fishes rearing in littoral areas of the Columbia River, and how observed signs of GBT may affect survival.

Objective 1. Examine salmonid fry and larval and juvenile resident fishes collected in shorelines for signs of GBT, and measure gas saturation levels in collection areas. We will focus on the Hanford Reach, because it contains spawning habitats of the last major population of mainstem Columbia River fall chinook salmon, with significant amounts of rearing habitat for newly-emerged (30-40 mm) fall chinook fry (Key et al. 1994), and in the area below Bonneville Dam because spawning habitats for salmonid stocks have been observed in vulnerable shallow shoreline areas.

Assumptions: (1) Abundances of salmonid fry and larval and juvenile resident fish overlap with periods of gas supersaturation.
(2) Fish in the field with signs of GBT can be sampled before direct or indirect mortality (due to increased vulnerability to predation) occurs. Objective 2 will test this assumption.

Objective 2. Determine how dissolved gas supersaturation may influence growth and survival by exposing salmonid fry and larvae or juveniles of resident fish to various levels of dissolved gas supersaturation in the laboratory. Additionally, expose fish with signs of GBT and control fish (no GBT signs) to predators to determine if GBT results in increased vulnerability to predation.

(H_o) Fish with signs of GBT show no significant differences in growth, survival, or vulnerability to predation compared to control fish.

Results will be presented in reports and in manuscripts for publication in peer-reviewed journals. This research will aid managers in assessing how DGS may affect survival of dominant Columbia River fish species during their early life history, a potentially critical period in the formation of year-class strength. In particular, little information is currently available on effects of DGS on fall chinook fry during their critical shoreline rearing period when they may be particularly vulnerable to GBT because depth cannot be used for hydrostatic compensation. These results would aid evaluation of hydrosystem operations such as timing and magnitude of spill at dams.

c. Rationale and significance to Regional Programs.

Objectives of the FWP are to determine symptoms of gas bubble trauma related to both lethal and non-lethal effects on juvenile and adult salmon and other aquatic species. Additionally, NMFS objectives are to develop and implement a monitoring and evaluation program to investigate the effects of dissolved gas supersaturation, and to continue field research correlating gas bubble disease signs with mortality of resident fish in the lower Snake and mid- and lower Columbia rivers. Some of these objectives are being addressed by current (FY98) Fish and Wildlife Program projects (CRITFC

#9300802 Symptoms of GBT; NMFS #9602200 Evaluating effects of dissolved gases ..; and USGS-BRD #9602100 GBD monitoring & research).

However, little research has been conducted on GBT in younger stages of salmonids, in particular fall chinook fry, or GBT in larval or juvenile resident fishes. Early life stages of fish could be particularly vulnerable to DGS because use of depth for hydrostatic compensation may be limited. Our study would supply information on these critical stages when year-class strength may be determined. Personnel involved in our study will collaborate with other researchers at the USGS-BRD Columbia River Research Laboratory who are already involved in GBT research. Expert technical assistance will be provided by Matt Mesa, Alec Maule, and John Beeman, all of the USGS-BRD. Additionally, we will coordinate with Paul Wagner of the Washington Department of Fish and Wildlife (WDFW) who is currently studying the effects of water-level changes on stranding of juvenile fall chinook salmon in shoreline areas of the Hanford Reach (BPA Project 9701400) .

d. Project history

e. Methods.

Objective 1. Examine salmonid fry and larval and juvenile resident fishes collected in shorelines for signs of GBT, and monitor gas saturation levels in collection areas.

Task 1. Collect salmonid fry and larval and juvenile resident fishes from shorelines in the Hanford Reach and below Bonneville Dam, Columbia River, using a small beach seine (15.2 m x 1.2 m with 2.0 mm mesh and a 1.2 m^2 bag lined with 0.8 mm mesh), or dipnets and buckets. Sample size will depend on the number of taxa collected and the levels and duration of supersaturation encountered

Task 2. Larvae and young juvenile fishes from collections will be anaesthesized with MS-222 buffered to a pH of 7 with sodium bicarbonate, identified to the lowest possible taxon following methods of Gadomski and Barfoot (In press), measured using an ocular micrometer fitted to a dissecting microscope, and examined for signs of GBT. Small larvae are nearly transparent, so internal bubbles should be evident, based on GBT research conducted on larval striped bass by Cornacchia and Colt (1984). Larger specimens will be examined for GBT using methodology developed for juvenile salmonids (Mesa and Warren 1997), with an initial scan for external gas bubbles in the lateral line, fins, eyes, and body surface, and if feasible, gill arch removal and examination under a compound microscope.

Assumptions: (1) Abundances of salmonid fry and larval and juvenile resident fish overlap with periods of gas supersaturation.
(2) Fish in the field with signs of GBT can be sampled before direct or indirect mortality (due to increased vulnerability to predation) occurs. Objective 2 will test this assumption.

Task 3.Use a TDG meter (Common Sensing, Inc., Clark Fork, Idaho) or a Weiss saturometer to monitor barometric pressure, water temperature, total gas pressure minus barometric gas pressure (delta *P*), and percent saturation .

Objective 2. Determine how dissolved gas supersaturation may influence growth, survival, and vulnerability to predation of salmonid fry and larvae and juveniles of key resident fish.

Task 1. Salmonid fry for experiments will be obtained from local hatcheries, most likely the Little White Salmon National Fish Hatchery, Cook, Washington. Larval and young juvenile resident fishes for experiments will be obtained by spawning adults in the laboratory or by collecting wild larvae or juveniles in areas with low levels of gas saturation. Fish will be exposed to various levels of dissolved gas supersaturation (105, 110, 120, 130% TDG) at the Columbia River Research Laboratory (supersaturated water is available at this facility, see Mesa et al. 1996; Mesa and Warren 1997). Growth and mortality will be monitored concurrent with observations of GBT signs, and compared with growth and mortality of control (unexposed) fish.

Task 2. Predation tests will be conducted following methods of Gadomski et al. (1994) and Mesa and Warren (1997), with adaptions for using smaller test fish. Smallmouth bass Micropterus dolomieui or northern squawfish Ptychocheilus oregonensis will be used as predators on salmonid fry or juvenile resident fish. Prey will be exposed to supersaturated water and signs of GBT monitored. For a test, equal numbers of exposed and unexposed (control) prey will be introduced into a tank containing predators. When approximately 50% of prey are consumed, fish will be removed and the proportions of exposed and control prey ingested will be tallied. (To facilitate identification of prey types, prior to experiments fish will be marked with fin-clips, specifically the adipose fin for salmonids). Data will be analyzed similarly to Mesa and Warren (1997) and Gadomski et al. (1994) using analysis of variance (ANOVA) and chi-square (X^2) goodness of fit tests.

f. Facilities and equipment.

Field work will be conducted using gear acquired for BPA Project 90-078, which includes a 19 ft aluminum boat with 90 hp outboard, and appropriate nets for collecting larval and juvenile fishes (Gadomski and Barfoot In press; Barfoot et al. In review). Laboratory work will be conducted at the USGS Columbia River Research Laboratory (CRRL), Cook, Washington. This facility has numerous fiberglass tanks of various sizes with flow-through well water which can be heated to a range of temperatures. Gas supersaturated water can be generated by a combination of heating and pumping well water under pressure and injecting atmospheric gas (Mesa and Warren 1997). Dissecting microscopes (Leica Wild M3 Z) with 8-40X zoom magnification are available at the CRRL for use in examining specimens for GBT. A TDG meter (Common Sensing, Inc., Clark Fork, Idaho) or a Weiss saturometer can possibly be borrowed from other projects at the CRRL, but the cost to purchase a gas meter has been included in the budget in the event these are unavailable.

g. References. Relevant manuscripts authored by the principal investigators.

Barfoot, Craig A., Dena M. Gadomski, & Robert H. Wertheimer. In review. Growth and mortality of age-0 northern squawfish Ptychocheilus oregonensis during early rearing in shoreline habitats of a Columbia River Reservoir, U.S.A. Environmental Biology of Fishes.

Barfoot, Craig A. In preparation. Changes in near-shore fish community composition in a lower Columbia River impoundment.

Gadomski, Dena M. & Craig A. Barfoot. In press. Diel and distributional abundance patterns of fish embryos and larvae in the lower Columbia and Deschutes rivers. Environmental Biology of Fishes.

Gadomski, Dena M., Craig A. Barfoot, Jennifer M. Bayer, & Thomas P. Poe. In preparation. Early life history of the northern squawfish Ptychocheilus oregonensis in the lower Columbia River and two tributaries.

Gadomski, D.M., and J.A. Hall-Griswold. 1992. Predation by northern squawfish on live and dead juvenile chinook salmon. Transactions of the American Fisheries Society. 121: 680-685.

Gadomski, D.M., M.G. Mesa, and T.M. Olson. 1994. Vulnerability to predation and physiological stress responses of experimentally descaled juvenile chinook salmon, Oncorhynchus tshawytscha. Environmental Biology of Fishes. 39: 191-199.

Mesa, M.G., T.P. Poe, D.M. Gadomski, and J.H. Petersen. 1994. Are all prey created equal? A review and synthesis of differential predation on prey in substandard condition. Journal of Fish Biology. 45: 81-96.

Petersen, J.H., and D.M. Gadomski. 1994. Light-mediated predation by northern squawfish on juvenile chinook salmon. Journal of Fish Biology. 45: 227-242.

Petersen, J.H., D.M. Gadomski, and T.P. Poe. 1994. Differential predation by northern squawfish (Ptychocheilus oregonensis) on live and dead juvenile salmonids in the Bonneville Dam tailrace (Columbia River). Canadian Journal of Fisheries and Aquatic Sciences. 51: 1197-1204.

Poe, T. P., H. C. Hansel, S. Vigg, D. E. Palmer, and L. A. Prendergast. 1991. Feeding of predaceous fishes on out-migrating juvenile salmonids in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120: 405-420.

Vigg, S., T. P. Poe, L. A. Prendergast, and H. C. Hansel. 1991. Rates of consumption of juvenile salmonids and alternative prey fish by northern squawfish, walleyes, smallmouth bass, and channel catfish in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120: 421-438.

Poe, T. P., R. S. Shively, and R. A. Tabor. 1994. Ecological consequences of introduced piscivorous fishes in the lower Columbia and Snake rivers. Pages 347-360, in D. J. Stouder, K. Fresh, and R. J. Feller (eds.), Theory and Application in Fish Feeding Ecology. Bell W. Baruch Library and Marine Sciences, No. 18, University of South Carolina Press, Columbia, South Carolina.

Other references.

Alderdice, D.F., and J.O.T. Jensen. 1985. An explanation for the high resistance of incubating salmonid eggs to atmospheric gas supersaturation of water. Aquaculture. 49: 85-88.

Counihan, T.D., A.I. Miller, M.G. Mesa, and M.J. Parsley. In press. The effects of dissolved gas supersaturation in white sturgeon larvae. Transactions of the American Fisheries Society.

Cornacchia, J.W., and J.E. Colt. 1984. The effects of dissolved gas supersaturation on larval striped bass, Morone saxatilis (Walbaum). Journal of Fish Diseases. 7: 15-27.

Dawley, E.M., and W.J. Ebel. 1975. Effects of various concentrations of dissolved atmospheric gas on juvenile chinook salmon and steelhead trout. Fishery Bulletin, U.S. 73: 787-796.

Hillson, T., P. Hoffarth, S. Lund, W. Price, R. Tudor, and P. Wagner. 1997. 1996 McNary Dam, Ice Harbor Dam, and Lower Monumental Dam Smolt Monitoring Program. Annual report to the Bonneville Power Administration, Portland, OR.

Jones, D., and D.H. Lewis. 1976. Gas bubble disease in fry of channel catfish (Ictalurus punctatus). The Progressive Fish-Culturist. 38: 41.

Key, L.O., R.D. Garland, and K. Kappenman. 1994. Nearshore habitat use by subyearling chinook salmon and non-native piscivores in the Columbia River. Pp. 64-79 In D.W. Rondorf and K.F. Tiffan (Eds.) Identification of the spawning, rearing, and migratory requirements of fall chinook salmon in the Columbia River Basin. Annual report to the Bonneville Power Administration, Portland, OR.

LaBolle, L.D., H.W. Li, and B.C. Mundy. 1985. Comparison of two samplers for quantitatively collecting larval fishes in upper littoral habitats. Journal of Fish Biology. 26: 139-146.

McDonough, P.M., and E.A. Hemmingsen. 1985. Swimming movements initiate bubble formation in fish decompressed from elevated gas pressures. Comparative Biochemical Physiology. 81: 209-212.

Mesa, M.G., J.J. Warren, K. Hans, and A.G. Maule. 1996. Progression and severity of gas bubble trauma in juvenile chinook salmon and development of non-lethal methods for trauma assessment. In Maule, A.G., Mesa, M.G., Beeman, J., Haner, P., Hans, K., and Warren, J.J. (Eds.) Gas bubble trauma monitoring and research of juvenile salmonids. Annual report to the Bonneville Power Administration, Portland, OR.

Mesa, M.G., and J.J. Warren. 1997. Predator avoidance ability of juvenile chinook salmon Oncorhynchus tshawytscha subjected to sublethal exposures of gas-supersaturated water. Canadian Journal of Fisheries and Aquatic Sciences 54: 757-764

.Nebeker, A.V., J.D. Andros, J.K. McCrady, and D.G. Stevens. 1977. Survival of steelhead trout (Salmo gairdneri) eggs, embryos, and fry in air-supersaturated water. Journal of the Fisheries Research Board of Canada. 35: 261-264.

Rucker, R.R., and P.M. Kangas. 1974. Effect of nitrogen supersaturated water on coho and chinook salmon. The Progressive Fish-Culturist. 36: 152-156.

Shrimpton, J.M., D.J. Randall, and L.E. Fidler. 1990. Assessing the effects of positive buoyancy on rainbow trout (Oncorhynchus mykiss) held in gas supersaturated water. Canadian Journal of Zoology. 68: 969-973.

Weitkamp, D.E., and M. Katz. 1980. A review of dissolved gas supersaturation literature. Transactions of the American Fisheries Society. 109: 659-702.

Zirges, M.H., and L.D. Curtis. 1975. An experimental heated-water incubation system for salmonid eggs. The Progressive Fish-Culturist. 37: 217-218.

Section 8. Relationships to other projects

Objectives of the FWP are to determine symptoms of gas bubble trauma related to both lethal and non-lethal effects on juvenile and adult salmon and other aquatic species. Additionally, NMFS objectives are to develop and implement a monitoring and evaluation program to investigate the effects of dissolved gas supersaturation, and to continue field research correlating gas bubble disease signs with mortality of resident fish in the lower Snake and mid- and lower Columbia rivers. Some of these objectives are being addressed by current (FY98) Fish and Wildlife Program projects (CRITFC #9300802 Symptoms of GBT; NMFS #9602200 Evaluating effects of dissolved gases ..; and USGS-BRD #9602100 GBD monitoring & research)

However, little research has been conducted on GBT in younger stages of salmonids, in particular fall chinook salmon fry, or GBT in larval or juvenile resident fishes. Early life stages of fish could be particularly vulnerable to DGS because use of depth for hydrostatic compensation may be limited. Our study would supply information on these critical stages when year-class strength may be determined. Personnel involved in our study will collaborate with other researchers at the USGS-BRD Columbia River Research Laboratory who are already involved in GBT research. Expert technical assistance will be provided by Matt Mesa, Alec Maule, and John Beeman, all of the USGS-BRD. Additionally, we will coordinate with Paul Wagner of the Washington Department of Fish and Wildlife (WDFW) who is currently studying the effects of water-level changes on stranding of juvenile fall chinook salmon in shoreline areas of the Hanford Reach (BPA Project 9701400) .

Section 9. Key personnel

Key project personnel have extensive experience relevant to the proposed project. Dena Gadomski (Principal investigator: Research Fishery Biologist GS-12; FTE 0.5) and Craig Barfoot (Project manager: Research Fishery Biologist GS-9; FTE 1.0) have conducted research on larval and juvenile fishes in limnetic and littoral areas of the Columbia River for the past five years (1993-1997; BPA Project 90-078), resulting in the following manuscripts: Gadomski and Barfoot (In press), Barfoot et al. (In review), Barfoot (In preparation), Gadomski et al. (In preparation). Additionally, Thomas Poe (Project leader: Supervisory Fishery Biologist GM-13) and Dena Gadomski have studied predation on juvenile salmonids in the Columbia River Basin resulting in the following manuscripts: Poe et al. 1991, Vigg et al. 1991, Gadomski and Hall Griswold (1992), Gadomski et al. (1994), Petersen and Gadomski (1994), Petersen et al. (1994), and Poe et al. (1994). Matt Mesa (Research Fishery Biologist GS-12) of the Columbia River Research Laboratory will act as technical advisor. He has four years of extensive experience on various aspects of gas bubble trauma in salmonid fishes (Mesa et al. 1994; Mesa et al. 1996; Mesa and Warren 1997).

Dena M. Gadomski, Principal Investigator
Research Fishery Biologist

School	Degree	Date
University of California, Berkeley	B.A. Biology	1976
Oregon State University, College of Oceanography	M.S. Biological Oceanography	1983

Current Employer: U.S. Geological Survey - Biological Resources Division, Columbia River Research Laboratory, Cook, Washington

Current Responsibilities: Currently I supervise a research study with the large-scale goal of examining the abundance and distribution of larval and juvenile fishes in the Columbia River Basin. The focus of this study is to understand the basic early life history of the northern squawfish Ptychocheilus oregonensis, a dominant predator of juvenile salmonids in this area.

Recent Previous Employment: Project Manager/Fisheries Scientist. Occidental College, VANTUNA Research Group, Los Angeles, CA, 1985-1989.

Expertise: Larval and juvenile fish ecology. Predator-prey interactions.

Recent Relevant Publications:

Gadomski, D.M., and C.A. Barfoot. In press. Diel and distributional abundance patterns of fish embryos and larvae in the lower Columbia and Deschutes rivers. Environmental Biology of Fishes.

Gadomski, D.M., M.G. Mesa, and T.M. Olson. 1994. Vulnerability to predation and physiological stress responses of experimentally descaled juvenile chinook salmon, Oncorhynchus tshawytscha. Environmental Biology of Fishes. 39: 191-199.

Mesa, M.G., T.P. Poe, D.M. Gadomski, and J.H. Petersen. 1994. Are all prey created equal? A review and synthesis of differential predation on prey in substandard condition. Journal of Fish Biology. 45: 81-96.

Petersen, J.H., and D.M. Gadomski. 1994. Light-mediated predation by northern squawfish on juvenile chinook salmon. Journal of Fish Biology. 45: 227-242.

Gadomski, D.M., and J.A. Hall-Griswold. 1992. Predation by northern squawfish on live and dead juvenile chinook salmon. Transactions of the American Fisheries Society. 121: 680-685.

Craig A. Barfoot, Project Manager
Research Fishery Biologist

School	Degree	Date
University of South Dakota	B.S. Biology	1989
Montana State University	M.S. Fish and Wildlife Management	1993

Current Employer: U.S. Geological Survey - Biological Resources Division, Columbia River Research Laboratory, Cook, Washington

Current Responsibilities: Currently I am a team leader for a project studying possible effects of lower Snake River drawdown on predation-related juvenile salmonid mortality. I am also involved in research examining the abundance and distribution of larval and juvenile fishes in the Columbia River Basin.

Recent Previous Employment: Research Assistant. Biology Department, Montana State University, Bozeman, MT, 1990-1992.

Expertise: Fish assemblage structure. Fish habitat requirements. Larval and juvenile fish ecology.

Recent Relevant Manuscripts:

Barfoot, C.A. In preparation. Changes in near-shore fish community composition in a lower Columbia River impoundment.

Barfoot, C. A., D.M. Gadomski, and R. H. Wertheimer. In review. Growth and mortality of age-0 northern squawfish Ptychocheilus oregonensis during early rearing in shoreline habitats of a Columbia River Reservoir, U.S.A. Environmental Biology of Fishes.

Gadomski, D. M., and C. A. Barfoot. In press. Diel and distributional abundance patterns of fish embryos and larvae in the lower Columbia and Deschutes rivers. Environmental Biology of Fishes.

Barfoot, C.A., D.M. Gadomski, A.M. Murphy, and G.T. Schultz. 1994. Reproduction and early life history of northern squawfish Ptychocheilus oregonensis in the Columbia River. pp. 7-40 In Gadomski, D.M. and Poe, T.P. (eds.), System-wide significance of predation. Annual report by the National Biological Survey to the Bonneville Power Administration, Portland, OR.

Barfoot, C.A. 1993. Longitudinal distribution of fishes and habitat in Little Beaver Creek, MT. M.S. Thesis. Fish and Wildlife Management, Montana State University, Bozeman, MT.

Thomas P. Poe, Project Leader
Supervisory Fishery Biologist

School	Degree	Date
Carroll College	B.S. Biology	1966
Northern Illinois University	M.S. Zoology	1972

Current Employer: U.S. Geological Survey - Biological Resources Division Columbia River Research Laboratory, Cook, Washington

Current Responsibilities: I serve as project leader for several fisheries research projects in the lower Columbia River. Studies focus on: (1) juvenile salmonid passage behavior at John Day, The Dalles, and Bonneville dams, (2) habitat use by larval and juvenile anadromous and resident fishes in lower Columbia River reservoirs, and (3) a graduate student research project comparing pre and post-impoundment river features in upper John Day Reservoir using a GIS to manipulate and analyze spatial and biological data.

Recent Previous Employment: Supervisory Fishery Biologist/Project Leader, U.S. Geological Survey, Biological Resources Division, Great Lakes Research Center, Ann Arbor, Michigan, 1979-1986.

Expertise: Applied behavioral ecology of fishes, specializing in predator-prey interactions, and on early life history studies, particularly focused on spawning and rearing habitat requirements .

Recent Relevant Publications:

Poe, T.P., R.S. Shively, and R.A.Tabor. 1994. Ecological consequences of introduced piscivorous fishes in the lower Columbia and Snake rivers. Pages 347-360, in D.J. Stouder, K. Fresh, and R.J. Feller (eds.), Theory and Application in Fish Feeding Ecology. Bell W. Baruch Library and Marine Sciences, No. 18, University of South Carolina Press, Columbia, South Carolina.

Poe, T.P., H.C. Hansel, S. Vigg, D.E. Palmer, and L. A. Prendergast. 1991. Feeding of predaceous fishes on out-migrating juvenile salmonids in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120: 405-420.

Vigg, S., T. P. Poe, L. A. Prendergast, and H. C. Hansel. 1991. Rates of consumption of juvenile salmonids and alternative prey fish by northern squawfish, walleyes, smallmouth bass, and channel catfish in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120: 421-438.

Matthew G. Mesa, Technical Advisor

Experience

1991-Present Research Fishery Biologist, U.S. Geological Survey, Biological Resources Division, Columbia River Research Lab, Cook, WA
Current responsibilities: Team leader on research projects addressing the effects of dissolved gas supersaturation on juvenile salmonids and evaluating predator-prey relations in Columbia River fishes

1989-1991 Fishery Biologist, U.S. Fish and Wildlife Service, Seattle-NFRC, Columbia River Field Station, Cook, WA

1986-1989 Fishery Biologist/CEA Appointee, Seattle-NFRC, Oregon Cooperative Fisheries Research Unit, Oregon State University, Corvallis, OR

1984-1986 Fishery Biologist, U.S. Fish and Wildlife Service, Seattle-NFRC, Columbia River Field Station, Cook, WA

Education: School	Degree and Date Received
California Polytechnic State University at San Luis Obispo	B.S., Nat. Res. Mgt., 1984
Oregon State University	M.S., Fisheries, 1989
Oregon State University	Advancement to candidacy for Ph.D, 1995

Expertise: My areas of expertise include predator-prey interactions in fishes, fish behavior and perfomance, and general and stress physiology of fishes.

Publications and Reports (five most relevant)

Mesa, M.G. and C.B. Schreck. 1989. Electrofishing mark-recapture and depletion methodologies evoke behavioral and physiological changes in cutthroat trout. Transactions of the American Fisheries Society 118:644-658.

Mesa, M.G. 1991. Variation in feeding, aggression, and position choice between hatchery and wild cutthroat trout in an artificial stream. Transactions of the American Fisheries Society 120:723-727.

Mesa, M.G. 1994. Effects of multiple acute stressors on the predator avoidance ability and physiology of juvenile chinook salmon. Transactions of the American Fisheries Society 123:786-793.

Mesa, M.G., T.P. Poe, D.M. Gadomski, and J.H. Petersen. 1994. Are all prey created equal? A review and synthesis of differential predation on prey in substandard condition. Journal of Fish Biology 45 (Supplement A):81-96.

Mesa, M.G., T.P. Poe, A.G. Maule, and C.B. Schreck. *In press*. Vulnerability to predation and physiological stress responses in juvenile chinook salmon experimentally infected with *Renibacterium salmoninarum*. Canadian Journal of Fisheries and Aquatic Sciences.

Section 10. Information/technology transfer

Results will be presented in reports and in manuscripts for publication in peer-reviewed journals. This research will aid managers in assessing how DGS may affect survival of dominant Columbia River fish species during their early life history, a critical period in the formation of year-class-strength.   In particular, little information is currently available on effects of DGS on fall chinook fry during their critical shoreline rearing period when they may be particularly vulnerable to GBT because depth cannot be used for hydrostatic compensation. These results would aid evaluation of hydrosystem operations such as timing and magnitude of spill at dams.